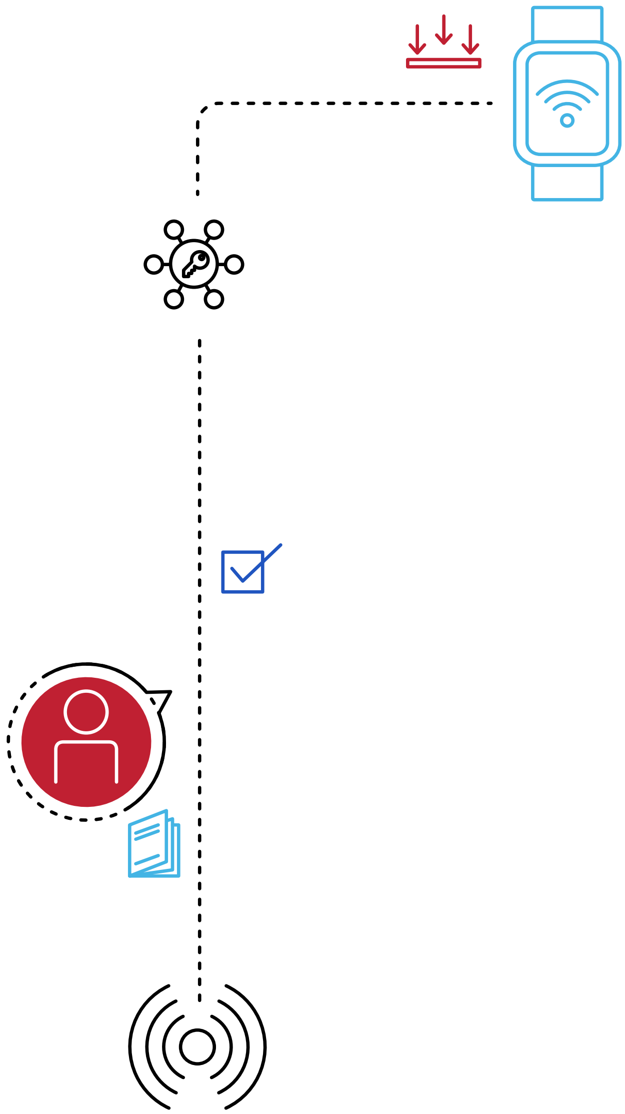
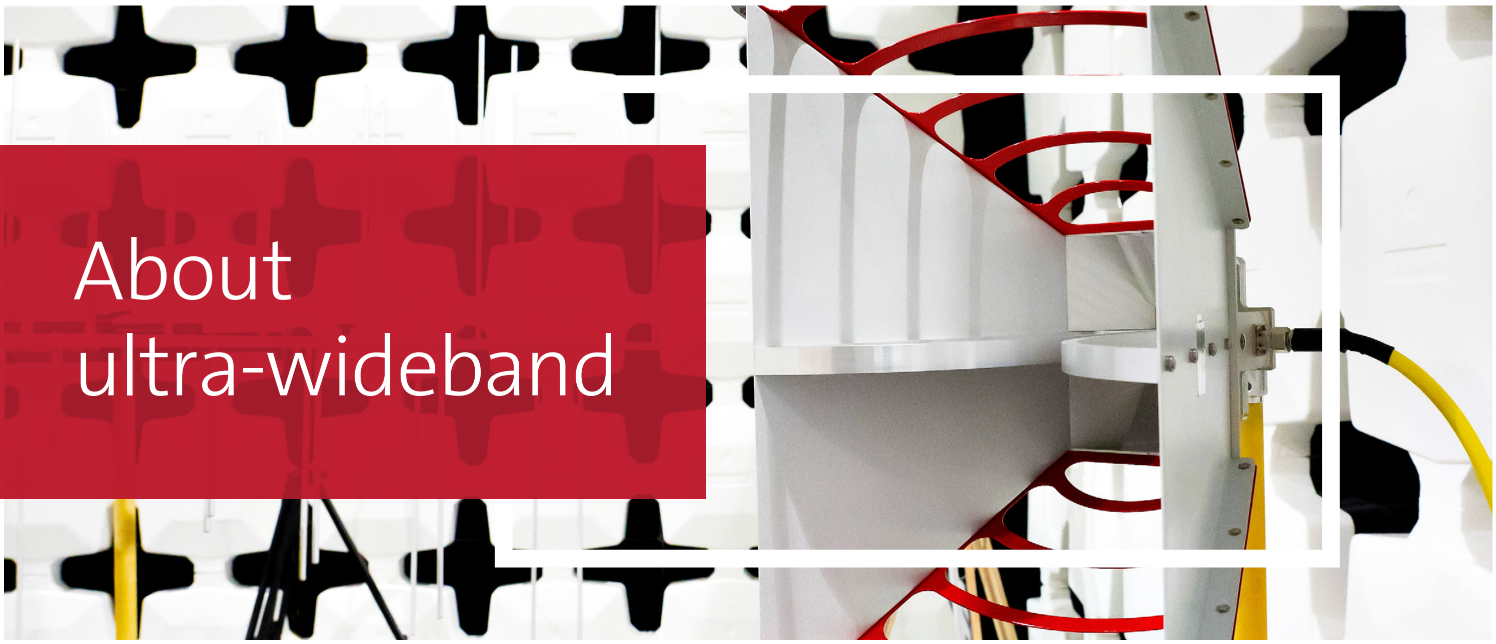


Ultra-Wideband Communications: What You Need to Know About Testing and Certification

Empowering Trust®

This white paper discusses the latest standards and regulatory requirements for testing ultra-wideband (UWB) devices and how they can be implemented and certified. The scope of the research includes UWB measurement methods using European Telecommunications Standards Institute (ETSI) documents for reference, test instrument specifications and pass/fail criteria for test results.



About ultra-wideband

While the Institute of Electrical and Electronics Engineers' (IEEE) initial IEEE 802.15.4a standard for ultra-wideband communications was released in 2006, there has been a slow but steady increase in its adoption into mainstream consumer electronics applications. Since 2018, the market has accelerated more rapidly — a May 2020 report from Techno Systems Research[1] estimated that the chip market alone for UWB stood at $485.9 million USD and forecast that it would reach $1.26 billion by 2025. In a 2020 independent report from Techno Systems Research, their projections support the UWB Alliance's position that UWB technology would be integrated more than a billion devices per year by 2025.

The catalyst for this increase in demand has been the suitability of UWB for the Internet of Things (IoT), i.e., devices equipped with internet-connected sensors and multiple radios that create and send data to a main platform. Additionally, new use cases emerged due to the technology's introduction as a standard feature in smartphones. Another catalyst is its inclusion in the automotive industry's Digital Key Release 3.0 specification, published by the Car Connectivity Consortium. Small consumer electronic devices, such as smartwatches and other wearables, are beginning to incorporate UWB technology. Consumer tags use UWB to help locate everyday objects.

Use cases for UWB

Many industries have applied UWB to their products, including healthcare, telecommunications and automotive. These applications are mostly centered around the technology's capabilities in high-rate data transmission, accurate positioning and proximity awareness.

Positioning

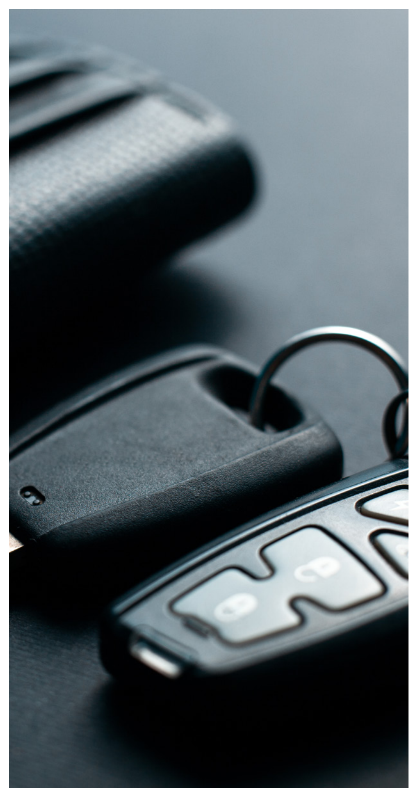
According to the FiRa Consortium, based on IEEE 802.15.4a, UWB can determine the relative position of a UWB object up to 200 meters away, with an accuracy down to 10 centimeters. This allows for the use of UWB to locate everyday objects fitted with UWB tags, such as wallets or car keys. It can also enable real time location services (RTLS). One potential use for RTLS could be in a hospital, tracking the movements and precise locations of vulnerable patients and physical assets.

Access control

The highly accurate positioning available with UWB also enables seamless access, such as keyless entry and ignition systems for vehicles using either a mobile phone or wearable device like a smartwatch. The car detects the user's approach via UWB and implements security and authentication, automatically unlocking and enabling the user to start the engine. The hands-free, location-aware features enabled by UWB connectivity offer an extremely user-friendly experience.

Rapid data transmission

Using UWB's characteristic broad bandwidth, data is transmitted in a short amount of time. Quick data transmission is beneficial for IoT sensors for which battery life is critical. A shorter transmission time is beneficial to minimize battery usage.



Standards and regulatory requirements for UWB testing

UWB can operate in a spectrum between 3 GHz and 9 GHz, with different regulatory bodies worldwide allocating other parts of this spectrum for local use. It is critical for original equipment manufacturers (OEMs) who want to achieve certification for their devices to be aware of the frequency and power constraints of UWB for any country in which their products will be used. apparatus may be used.

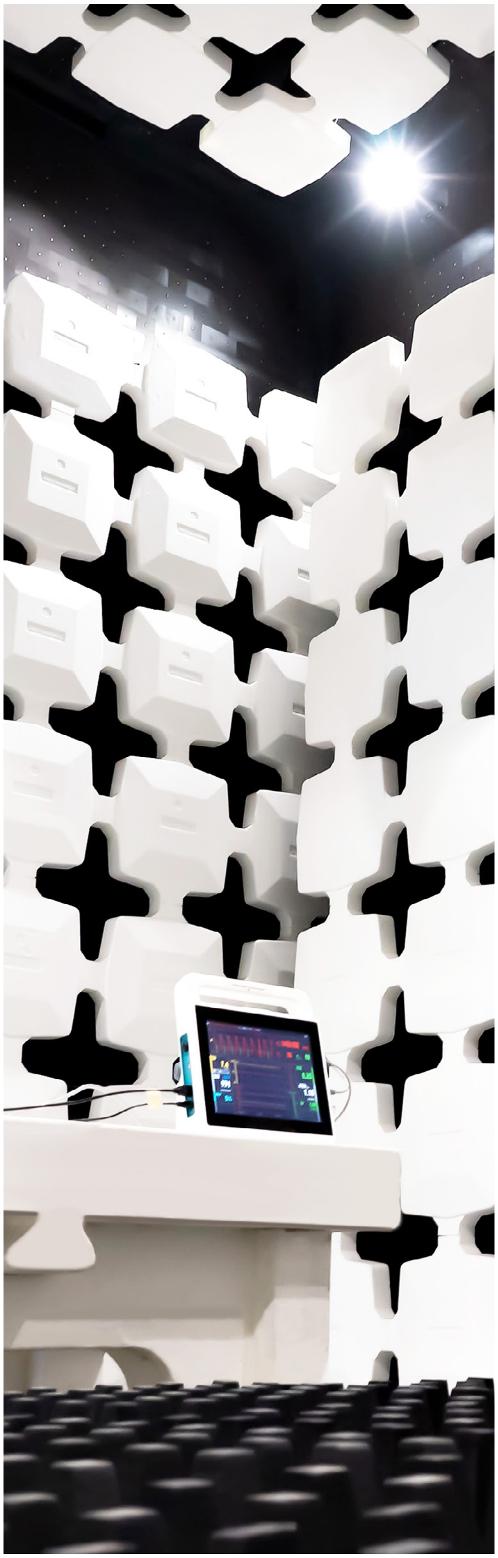
Partnering with a trusted resource, such as UL's Global Market Access service, can help OEMs enter their preferred market(s) as well as provide details regarding requirements and regulations for certain markets. Regulatory compliance, performance testing and certification are among the most important considerations. Table 1 summarizes the technical parameters for various regions, while Table 2 lists the standard references and status of the relevant standards authorities.

Table 1 — International radio frequency (RF) specifications for UWB

Spectrum Authority	Frequency Range (GHz)	Bandwidth (MHz)	Power
European Union	3.1–4.8 6.0–9.0	> 50	0 dBm/ 50 MHz peak -41.3 dBm/MHz average
U.K.	3.1–4.8 6.0–9.0	> 50	0 dBm /50 MHz peak -41.3 dBm/MHz average
U.S.	1.99–10.6	> 50 or > 500	0 dBm/50 MHz peak -41.3 dBm/MHz average
Canada	3.1–10.6	> 50 or > 500	0 dBm/50 MHz peak -41.3 dBm/MHz average

Table 2 – International regulators and UWB standards

Region/Authority	SDO	Standard	Status
EC	ETSI	EN 302 065-X series	Draft published
FCC	ANSI (FCC)	Part 15.250 or 15F	Current
ISED Canada	ANSI (ISED Canada)	RSS-210 Annex K or RSS-220	Current
U.K.	ETSI	EN 302 065-X series	Draft published



Summary of ETSI specifications

ETSI EN 302 065-1[2] specifies two frequency ranges within which a UWB device can operate: 3.1 to 4.8 GHz and 6.0 to 9.0 GHz. First, determine the operating bandwidth of the UWB device under test (DUT). Then work out the required limits for other parameters and identify the appropriate measurement procedures, which are defined as the -10 dBc bandwidth of the intended UWB signal under normal operational conditions. A single UWB device may have more than one operating bandwidth.

The parameters required to be measured are:

- Operating bandwidth(s) are measured between -10 dBc points.
- Maximum mean power spectral density is measured as effective isotropic radiated power (EIRP) — this is defined as the average power per unit bandwidth radiated in the direction of maximum power. The specified limit is -41.3 dBm/MHz.
- Maximum peak power (EIRP) is the peak power in a 50 MHz bandwidth, measured at the frequency at which the highest mean radiated power occurs and in the direction of maximum radiated power level.
- Receiver spurious emissions are specified within the operating bandwidth and at some other identified frequencies.
- Other emissions (OEs) can include the receiver and other analog or digital circuitry emissions and those from the UWB transmitter.
- A low duty cycle (LDC) specifies that the transmitter's maximum on-time should be less than 5 milliseconds per transmission, and the mean transmitter off-time should be 38 milliseconds or more average over 1 second. The sum of the transmitter on-time must be less than 18 s per hour, and the sum of the off-time must be greater than 950 milliseconds per second.
- Detect and avoid is a mitigation technique to avoid interference with other devices operating in the same band.

ETSI also specifies the type of test site that should be used, with an anechoic chamber being the preferred test site. The dimensions of the test site should be long enough to help ensure that all measurements are made in the far-field of the unit under test. If the anechoic chamber has a conductive ground plane, you must cover the ground with RF-absorbent material.

Summary of ETSI test methods

Some alternative test methods are defined in ETSI TS 102 883[3], and each is subdivided into procedures for a calibrated setup and an uncalibrated setup, respectively. Uncalibrated procedures rely on the substitution method. The DUT is replaced by a substitution antenna of known gain connected to a calibrated signal generator once the measurements have been recorded on the spectrum analyzer. The input signal to the test antenna is then adjusted to produce the same level on the spectrum analyzer that was recorded using the DUT. Figure 1 shows the generic test setup where either the receive antenna or the DUT can be moved to find the angle of maximum radiation.

For far-field measurements, the distance (*d*) is specified by

$$d \geq \frac{(d_1 + d_2)^2}{\lambda}$$

In this formula, *d1* is the largest dimension of the DUT or the substitution antenna, *d2* is the largest dimension of the test antenna and λ is the test frequency wavelength, with all quantities measured in the same units.

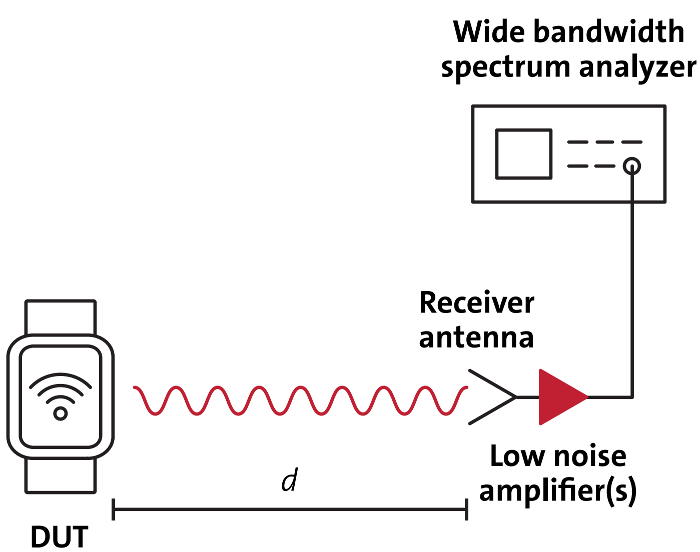


Figure 1 — Generic test setup for UWB radiated measurements

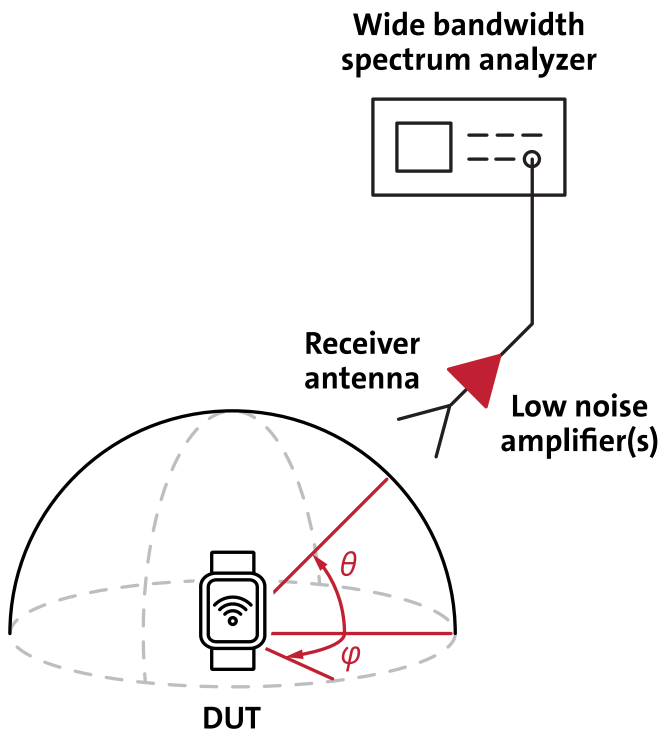


Figure 2 — Test setup for spherical scan with automatic test antenna placement

1. Spherical scan with automatic test antenna placement

   Figure 2 shows the method for spherical scanning with automatic test antenna placement. The receiver (RX) antenna can be moved stepwise around a sphere, measuring in each position. To perform a half-sphere scan, vary the elevation angle θ from 0° to 90° and the azimuth angle φ from 0° to 360°, with step sizes in each case being less than 5°.

2. Spherical scan with rotating device

   In this method, the DUT itself is rotated rather than moving the test antenna around it. Both the DUT and receive antenna need to be movable in the vertical axis. The scan is performed by rotating the DUT for θ from 0° to -90° and for φ from 0° to 360°.

Constraints of test method

Because of the wideband nature of UWB, peak power must be measured across a specified bandwidth — generally 50 MHz — rather than at a single frequency. Measuring peak power requires a spectrum analyzer with the capability to measure this resolution bandwidth. However, many typical baseline spectrum analyzers are specified with a maximum resolution bandwidth of either 10 or 20 MHz. Although it is possible to measure in a lower-resolution bandwidth and apply a correction factor, this overestimates the result. For accurate results, be sure to measure with a 50 MHz resolution bandwidth. Because of this, the UL laboratory test setup uses a state-of-the-art spectrum analyzer with an 80 MHz resolution bandwidth option.

The U.S. Federal Communications Commission's UWB emissions limits are particularly stringent, requiring low noise levels in measurement equipment to offer sufficient sensitivity. UL uses multiple preamplifiers, including high-gain units with low noise, to improve measurement sensitivity.

UL testing and certification services for UWB

Equipment and devices using UWB must meet the country's national radio frequency requirements where such products will be used or distributed. UL provides testing and certification services to meet the requirements in most markets and according to the relevant spectrum authority.

UWB testing and certification is available for a range of product types, including:

- Smartphones and accessories
- Automotive products
- Industrial devices
- Consumer technology
- Consumer wearables

A suite of testing and certification services for other OEM and regulatory agency requirements are also available at UL's laboratory. These include specific absorption rate (SAR) and electromagnetic compatibility (EMC) and can be performed on the product concurrently with its UWB testing.
The laboratory also provides a facility for customers to view testing over a live video link, enabling them to speak with the engineers testing their products in real time.

UL's certification capabilities

UL's laboratories provide full-service RF, SAR and EMC testing capabilities and are accredited to ISO/IEC 17025.

The Enhanced and Smart UL Certification Mark and UL Certification Badge can be used for specific UL certifications, providing added clarity and acceptance in the market and giving greater transparency into a product's compliance with the benefit of easier end-user access to relevant product information.

Learn more at UL.com.

Endnotes

1. Techno Systems Research. "2020 Ultra Wideband Market Analysis." May 2020. https://www.t-s-r.co.jp/en/report/3445/.

2. ETSI EN 302 065-1 V2.1.1 (2016-11). Harmonised European Standard. "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Requirements for Generic UWB applications." https://www.etsi.org/deliver/etsi_en/302000_302099/30206501/02.01.01_60/en_30206501v020101p.pdf.

3. ETSI TS 102 883 V1.1.1 (2012-08). Technical Specification. "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques. https://www.etsi.org/deliver/etsi_ts/102800_102899/102883/01.01.01_60/ts_102883v010101p.pdf.

UL.com